TESTS II

BJT

(1) conditions for amplifier and switch operation.

(2) CE, CC and CB sketches. (3) reasons for coupling capacitors.

(4) effect of bypass capacitor (5) emitter follower and its advantage.

(6) telling the amplifier type and switch state from their respective input/output waveforms. (7) transistor switch versus diode switch.

(8) comparison of amplifier types with those of the ideal amplifier as regards A_v, A_i, Z_I and Z_o.

FET

(1) their uses.

(2) comparison with BJT regarding size, power consumption, input impedance, handling and switching time.

Op-Amp

(1) definitions and/or ideal values for the op-amp following attributes: A_v, Z_i, Z_o, BW, slew rate, V_+, V_-, I_+, I_-, virtual ground and virtual short circuit.

(2) input/output formulas for: inverting, noninverting, summing, integrating, differentiating, comparator and voltage follower op-amps.

(3) sketching the o/p waveform due to a given i/p waveform for the op-amps in (2) upto saturation.

(4) subtraction using single and double op-amps.

(5) designing one or, more op-amp circuits to produce a specific o/p value for given input value(s).

(6) same as (5) but with prespecified op-amp types.

(7) expect the inverse problem; finding the i/p and circuit which produce a given o/p.

(8) How far is the ideal op.amp compatible with the desired characteristics of amplifiers?

(9) why the desired ccs in (8) are really desired.

(10) op-amp buffer and its advantages.

Multivibrators

(1) types, waveforms and uses of each type.

(2) other known names for the types in (1).

(3) implementation using the IC 555 timer.

END

Part (1)

BJT and FET

Part (1)

Bipolar Junction Transistor (BJT)

Filed Effect Transistor (FET)

[1] Conditions for amplifier and switch operation.

[2] CE, CC and CB sketches.

[3] Reasons for coupling capacitors.

[4] Effect of bypass capacitor.

[5] Emitter follower and its advantage.

[6] Telling the amplifier type and switch state from their respective input/output waveforms.

[7] Transistor switch versus diode switch.

[8] Comparison of amplifier types with those of the ideal amplifier as regards A_v, A_i, Z_i, and Z_o.

[9] Their uses (FETs).

[10] Comparison with BJT regarding size, power consumption, input impedance, handling and switching time.

$\boxed{1}$ Conditions for amplifier and switch operation:

⇒ Amplifier Conditions:

(1) DC Biasing: "Active region"

EBJ → FB

CBJ → RB

(2) Use CE or CB Configurations for Voltage Amp.

Use CE or CC Configurations for Current Amp.

⇒ Switch Conditions:

(1) DC Biasing: "Sat. and Cutoff regions"

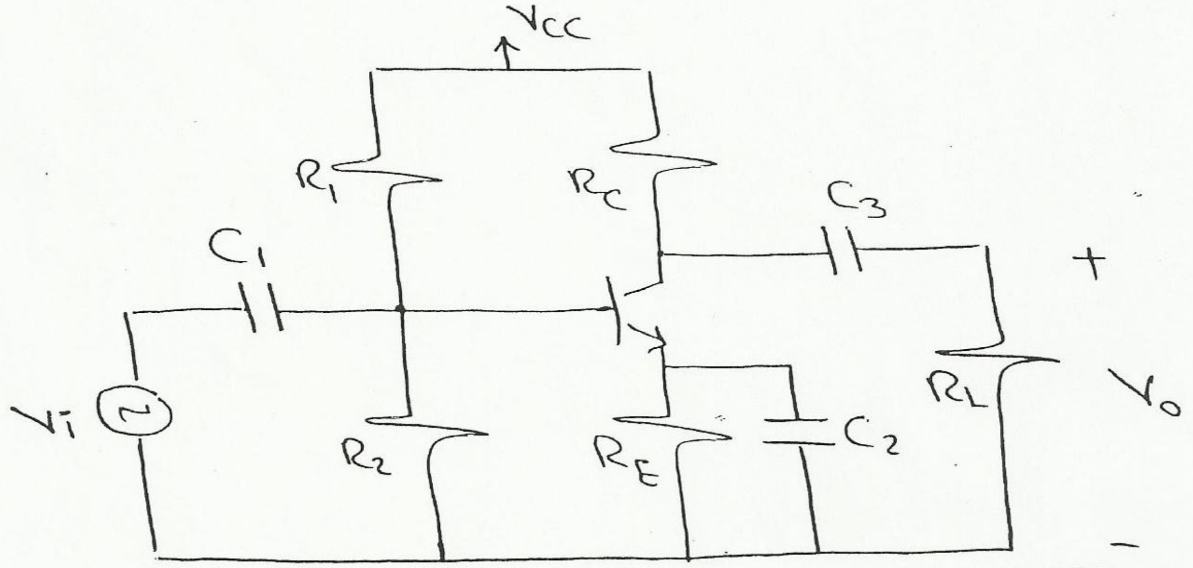
Sat ⇒ EBJ, CBJ → FB $\boxed{\text{ON}}$

Cutoff ⇒ EBJ, CBJ → RB $\boxed{\text{off}}$

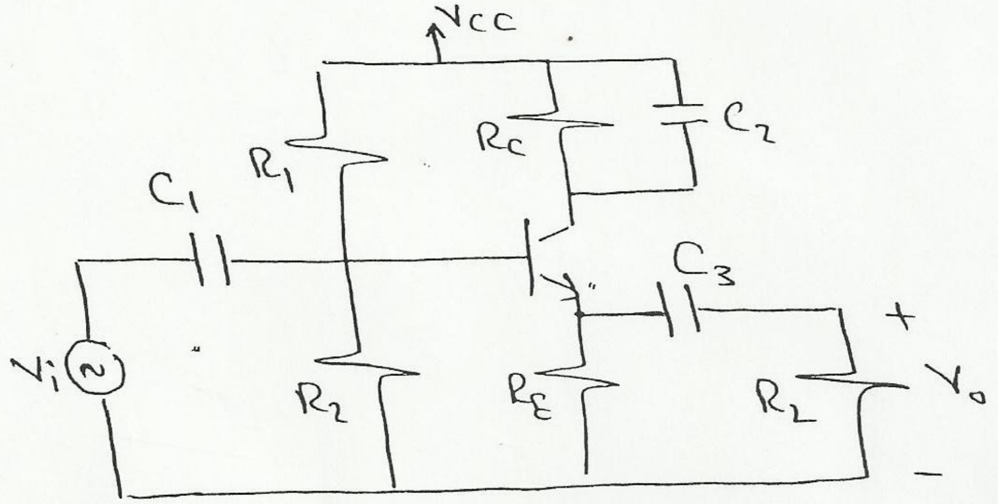
$\boxed{2}$ CE, CC, and CB Sketches:

"يريد رسم الدائرة الخاصة بكل نوع"

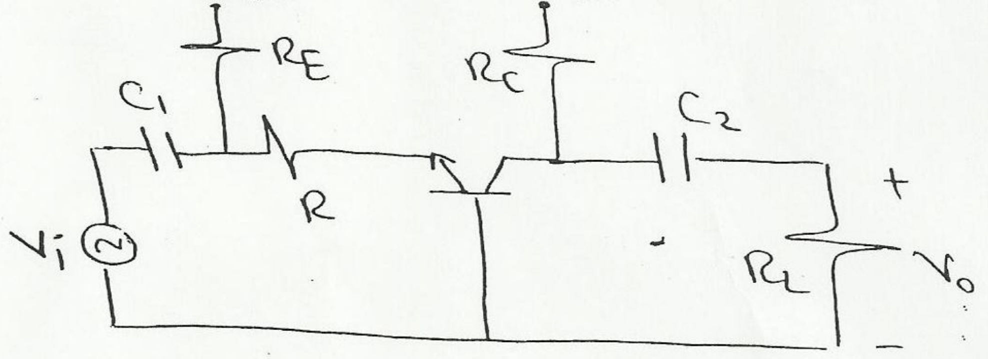
⇒ **CE** : i/P → B   o/P → C



⇒ **CC** : i/P → B   o/P → E



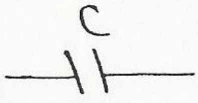
⇒ **CB** : i/P → E   o/P → C



3 - Reasons for Coupling Capacitors:

(1) It used to block the DC Component of Voltage and Current from reaching the BJT or the load.

$$Z_C = \frac{1}{j\omega C} \quad (\text{for DC} \rightarrow \omega \doteq 0)$$



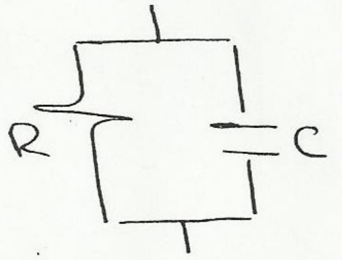
$$\therefore Z_C = \frac{1}{0} = \infty \rightarrow (\text{O.C}) \text{ for DC.}$$

(2) Increase the Q-Point stability of BJT.

4 Effect of bypass Capacitor:

(1) It is used to increase the gain of the transistor amplifier.

(2) It has no effect on the Q-Point.



DC-Analysis: C → O.C
Q-point ≡ the Same

Ac-analysis: C → S.C ($Z_{eq}=0$)
gain = ↑↑

[5] Emitter follower and its advantages:

⇛ Draw the Cir. of CC Config. (if needed).

⇛ Advantages:

(1) $A_I = \uparrow\uparrow$.

(2) $R_{in} = \uparrow\uparrow$.

(3) $R_{out} = \downarrow\downarrow$.

(4) Phase shift $= 0^\circ$.

(5) Can be used as a "voltage buffer".

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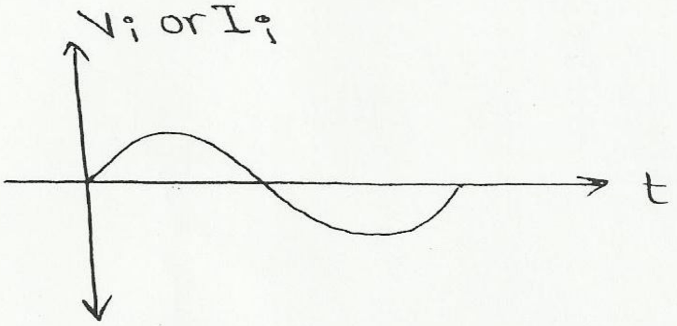
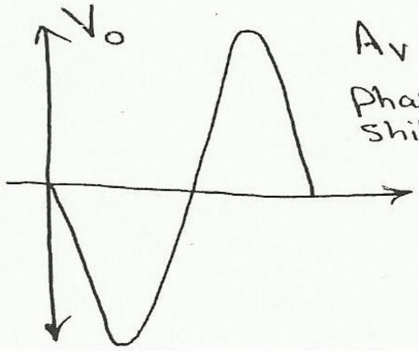
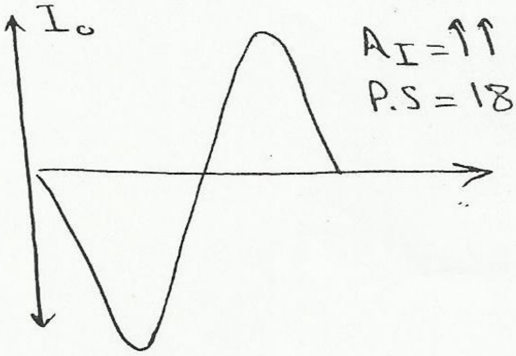
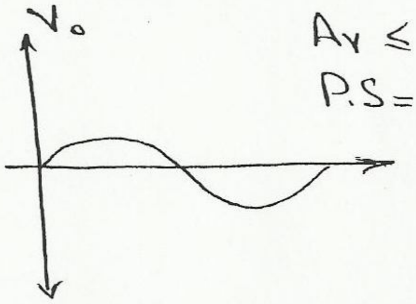
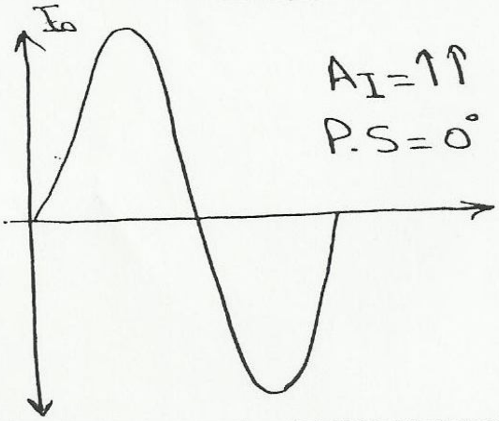
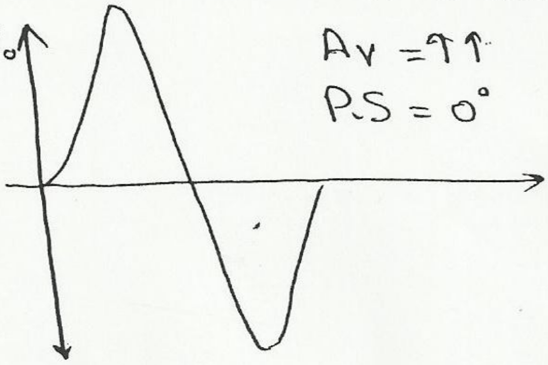
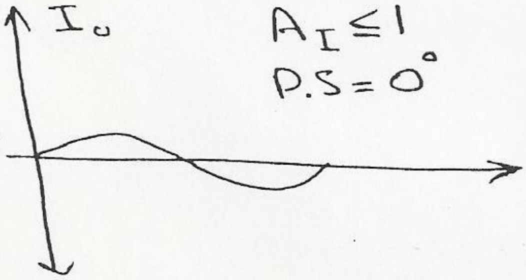
[6] Amp. Type (CE, CC, or CB).

Switch State (ON, off).

⇛ Amp. Type ⇚

⇛ Assume the i/P voltage or Current signal is:



Type	O/P Voltage	O/P Current
CE	 $A_V = \uparrow\uparrow$ Phase shift $= 180°$	 $A_I = \uparrow\uparrow$ P.S $= 180°$
CC	 $A_V \leq 1$ P.S $= 0°$	 $A_I = \uparrow\uparrow$ P.S $= 0°$
CB	 $A_V = \uparrow\uparrow$ P.S $= 0°$	 $A_I \leq 1$ P.S $= 0°$

⇛ Switch State ⇚

(BJT as SW)

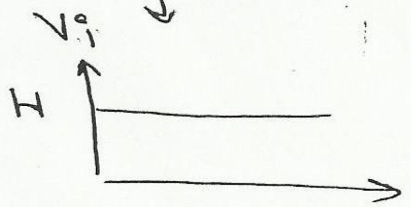
ملحوظة هامة : ال BJT يعمل كمفتاح (SW) ويمكن

(inverter) S

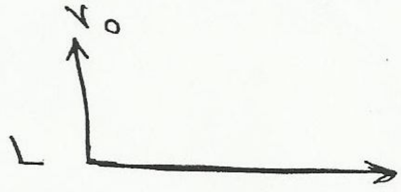
$V_i = H$ BJT → (Sat) $\therefore V_o = L$

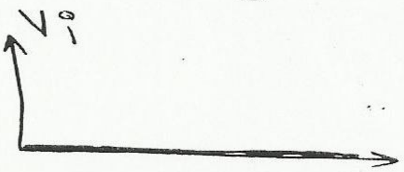
$V_i = L$ BJT → (Cutoff) $\therefore V_o = H$

BJT SW

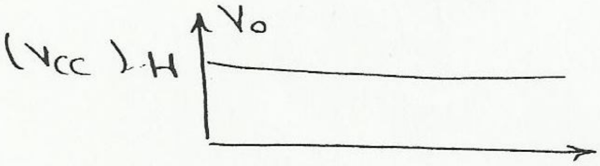


BJT (Sat) → S.C



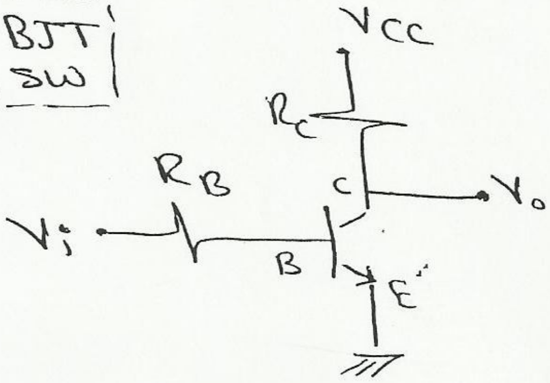


BJT (Cutoff) → O.C



7 Transistor SW VS. Diode SW:

BJT SW



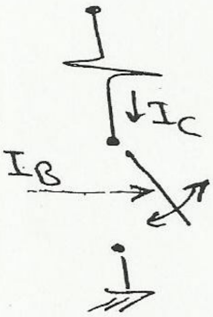
- $V_i = H$ BJT (Sat → S.C)

  $V_C = V_E$ V_o = zero (L)

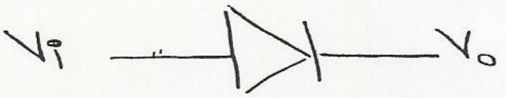
- $V_i = L$ BJT (Cutoff → O.C)

  $V_C = V_{CC}$ $V_o = V_{CC}$ (H)

التيار المتحكم في ال SW
هو ال I_B ولكن
التيار الذي يمر خلال ال
ال SW هو ال I_C



Diode SW

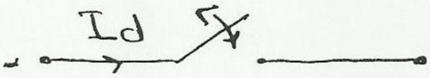


- $V_i = H$ D → FB (S.C)

  $V_o = H$

- $V_i = L$ D → RB (O.C)

  $V_o = L$



التيار المتحكم في ال SW هو
نفسه التيار الذي يمر خلاله
I_d

8 Amp. Types Comparison:

Parameter	CE	CC	CB	Ideal
A_v	$A_v = \uparrow\uparrow$ $P.S = 180^\circ$	$A_v \leq 1$ $PS = 0^\circ$	$A_v = \uparrow\uparrow$ $PS = 0^\circ$	$A_v = \infty$ $PS = 0^\circ$
A_I	$A_I = \uparrow\uparrow$	$A_I = \uparrow\uparrow$	$A_I \leq 1$	$A_I = \infty$
Z_{in}	$Z_{in} = \uparrow\uparrow$	$Z_{in} = \uparrow\uparrow$	$Z_{in} = \downarrow\downarrow$	$Z_{in} = \infty$
Z_o	$Z_o = \uparrow$	$Z_o = \downarrow\downarrow$	$Z_o = \downarrow$	$Z_o = 0$

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9 FET uses (Apps):

(1) Amplification.

(2) Switching.

(3) used to build ICs (نظراً لصغر حجمه).

\10\ Comparison betⁿ BJT and FET:

Parameter	BJT	FET
Size	Larger	Smaller
power Consumption	higher	lower
Z_{in}	relatively lower than FET.	higher for CS ($Z_{in} = \infty$)
handling	easy handling (easily)	handled with Care (to prevent it from destroy).
Switching time	faster	Slower

Part (2)

Op-Amp

Part (2)

Operational Amplifier (Op-Amp)

[1] Definitions and / or ideal values for the op-amp following attributes: A_v, Z_i, Z_o, BW, slew rate, V_+, V_-, I_+, I_-, virtual ground and virtual short circuit.

[2] Input / output formulas for: inverting, noninverting , summing , integration , differentiating , comparator and voltage follower op-amp.

[3] Sketching the o/p waveform due to a given i/p waveform for the op-amps in [2] up to saturation.

[4] Subtraction using single and double op-amp.

[5] Designing one or more op-amp circuits to produce a specific o/p value for given input value(s).

[6] Same as [5] but with prespecified op-amp types.

[7] Expect the inverse problem; finding the i/p and circuit which produce a given o/p.

$\boxed{I}$ OP_Amp attributes definetions :

⇛ $A_V = \frac{V_o}{V_i}$ ≡ Voltage gain

$A_V\big|_{Ideal} = \infty$

⇛ $Z_i = \frac{V_i}{I_i}$ ≡ I/P impedance

$Z_i\big|_{Ideal} = \infty$

⇛ $Z_o = \frac{V_o}{I_o}\Big|_{V_i \,\&\, \text{indep. sources} \rightarrow \text{zero}}$ ≡ O/P imp.

$Z_o\big|_{Ideal} = \text{zero}$

⇛ BW ≡ Bandwidth : is the freq range in which the OP_Amp Can operate normally or properly.

$BW\big|_{Ideal} = \infty$

⇛ SR ≡ Slew rate $= \frac{dV_o}{dt}\Big|_{max}$.

$SR\big|_{Ideal} = \infty$

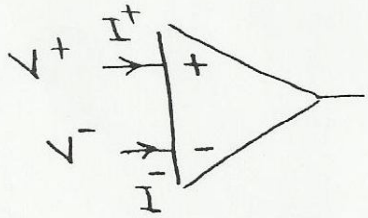
هو أقصى معدل لتغير الخرج بحيث لا يحدث له تشوه

⇛ V^- : inverting port voltage .

⇛ V^+ : noninv. port " .

⇛ I^- : inv. " Current .

⇛ I^+ : noninv. " " .



Ideally
$V^+ = V^-$
$\& \; I^+ = I^- = 0$

⇛ **Virtual ground :** إعتبار نقطة ما موصلة بالأرض

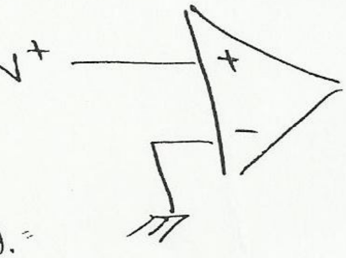
على الرغم من عدم وجود وصلة بينها وبين ال ground .

as $V^+ = V^-$

$V^- = 0V$

$\therefore V^+ = 0V \rightarrow$

virtual ground.



⇛ **Virtual Short Cir. :**

إعتبار جهد نقطة ما مساوى لجهد نقطة أخرى على الرغم من عدم

وجود S.C بينهما .

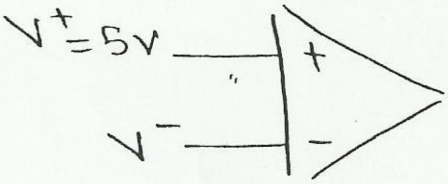
$V^+ = 5V$

$V^+ = V^-$

$\therefore V^- = 5V \rightarrow$

Virtual S.C betn

V^+ and V^-



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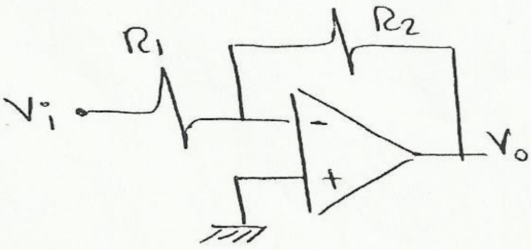
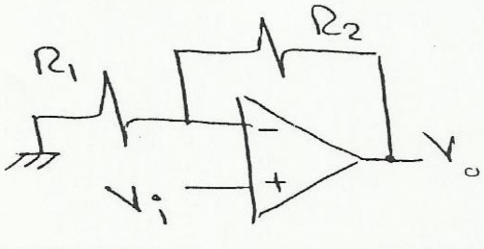
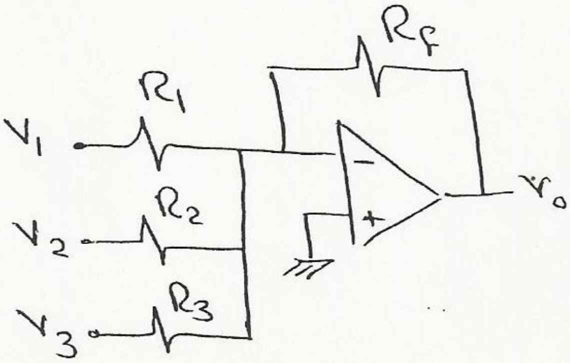
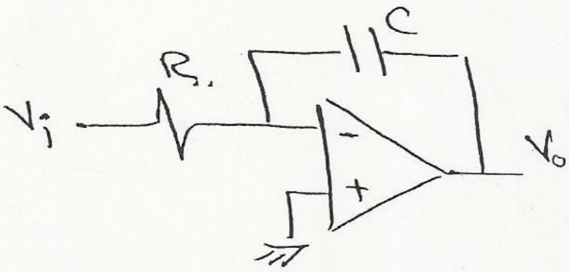
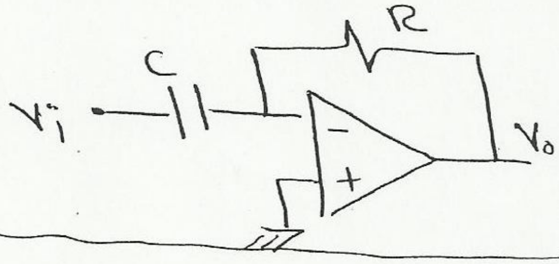
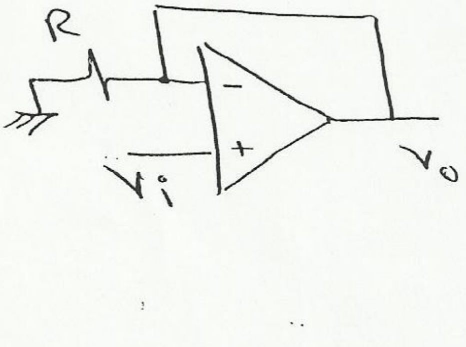
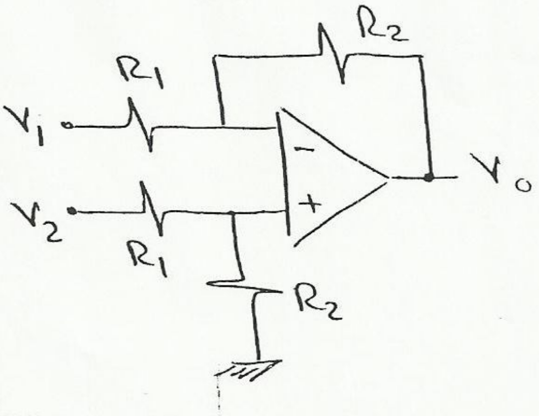
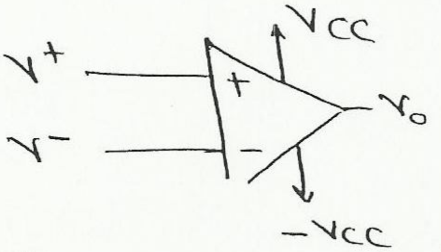
[2] مطلوب حفظ الدائرة ومعادلة الخرج لجميع

دوائر ال OP_Amp المذكورة

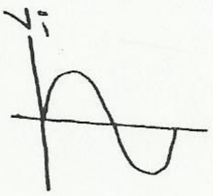
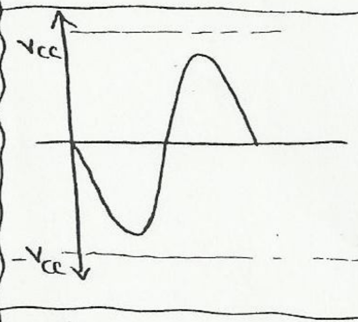
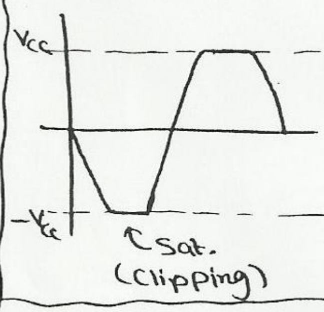
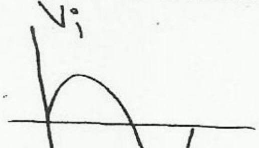
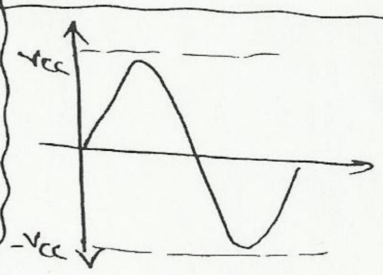
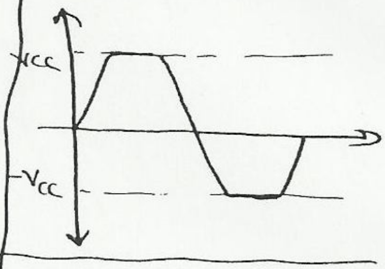
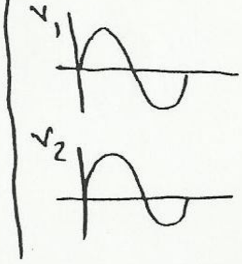
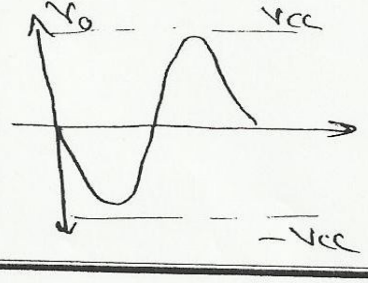
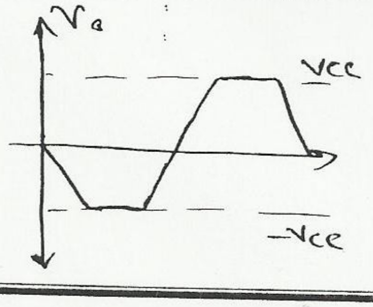
(a) Circuits → for design.

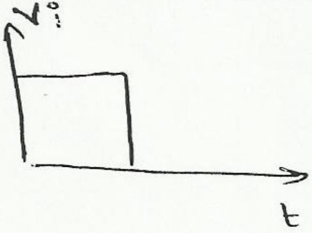
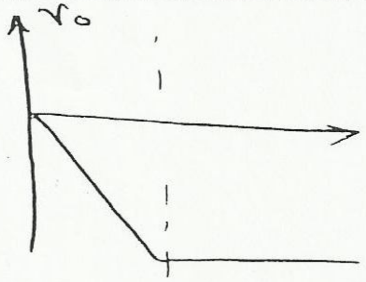
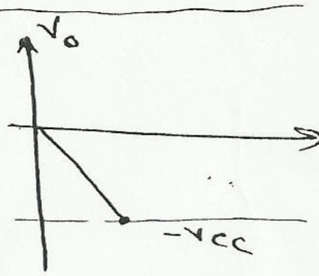
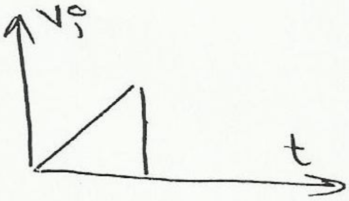
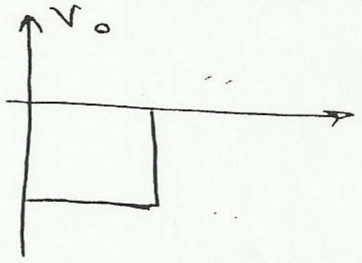
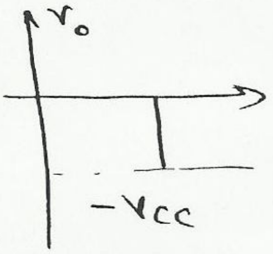
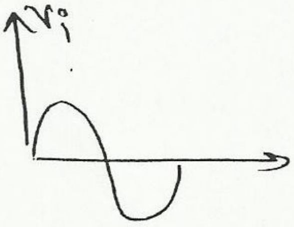
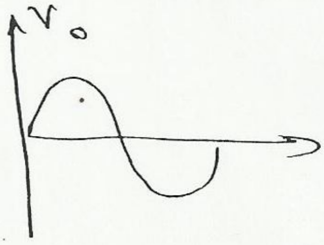
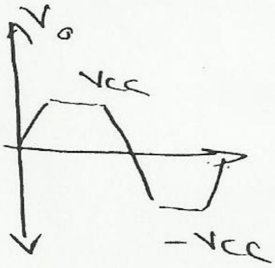
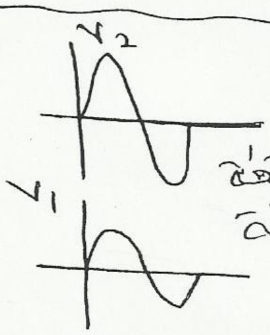
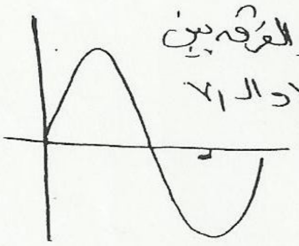
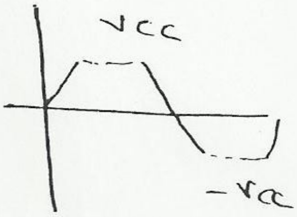
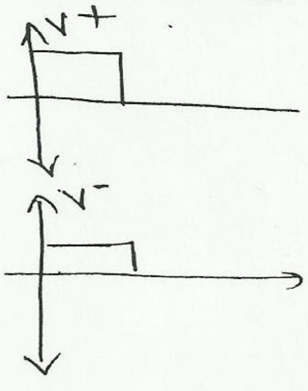
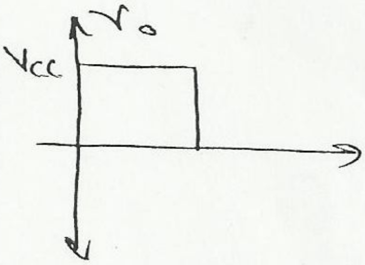
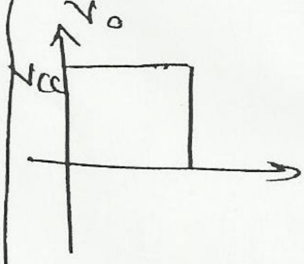
(b) V_o relations → for Calculations.

Type	Cir.	V_o relation
inverting Amp		$V_o = -\frac{R_2}{R_1} V_i$
noninverting Amp.		$V_o = \left(1 + \frac{R_2}{R_1}\right) V_i$
Summing Amp.	 R_f R_1 R_2 R_3 V_1 V_2 V_3 V_o - +	$V_o = -R_f\left[\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right]$
Integrating Amp.		$V_o = -\frac{1}{RC}\int V_i \, dt$
Differentiating Amp.		$V_o = \frac{-1}{RC} \frac{dV_i}{dt}$
Voltage follower OP_Amp.		$V_o = V_i$

Type	Cir.	V_o relation
Subtraction Amp.	 R_2 R_1 V_1 V_2 R_1 R_2 − + V_o	$V_o = \frac{R_2}{R_1}(V_2 - V_1)$
Comparator ~~Amp.~~		$V_o = \begin{cases} V_{cc} & V^+ > V^- \\ -V_{cc} & V^+ < V^- \end{cases}$

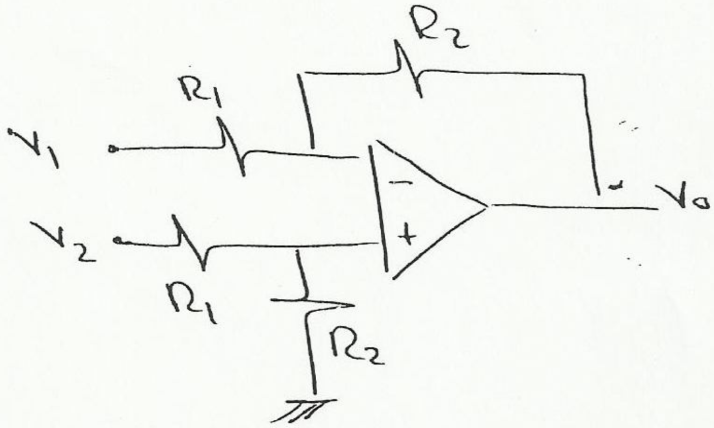
|3|

Type	"I/P"	"normal-O/P"	"Saturated O/P"
inv. Amp.			
noninv. Amp.			
Summing Amp.	 نجمع نقطة بنقطة		

Type	i/p	normal_o/p	Saturated o/p
Int. Amp			
Diff. Amp.			
Voltage follower			
Subtrac. Amp.	 نطرح نقطة بنقطة	 تكبير الفرق بين ال V_2 و ال V_1	
Comparator			

[4] Subtraction using single and double OP-Amps:

Single: Subtraction amp:

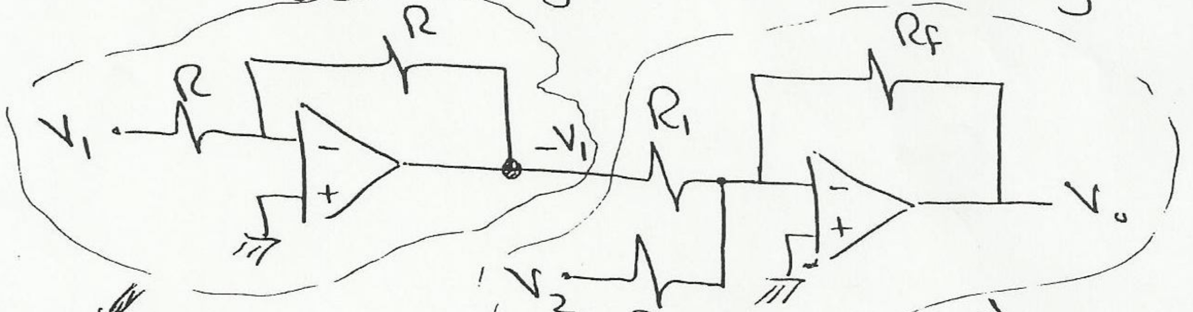


$$V_o = \frac{R_2}{R_1}(V_2 - V_1)$$

Double: وهنا تبدأ مسائل إل design وهذه المسائل يمكن أن يكون لها عدة حلول

مثل :

⇒ Using inverting amp and summing amp



Inverting amp

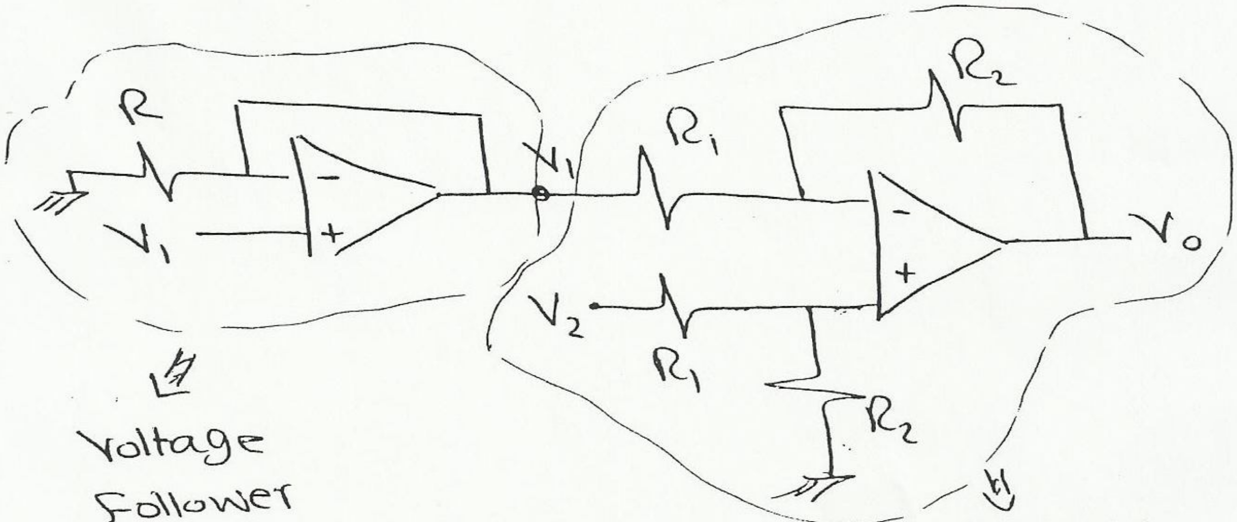
لإضافة إشارة سالبة للخرج

$$\therefore V_o = -R_f\left[\frac{V_2}{R_2} - \frac{V_1}{R_1}\right]$$

Summing amp

لجمع الجهدين V_2 & $-V_1$ وبذلك نحل عملية طرح .

⇒ OR : Using voltage follower and Subtraction amp :



Voltage Follower
$V_o = V_i$

Subtraction Amp.
الطرح

---

5 Given : V_i and V_o of a Cir.

Req : Design this Cir صمم هذه الدائرة

Solution

⇒ Ex.1 : $V_i = 3V$ $V_o = 30V$

Solution

using non-inverting amp : $V_o = \left(1 + \frac{R_2}{R_1}\right) V_i$

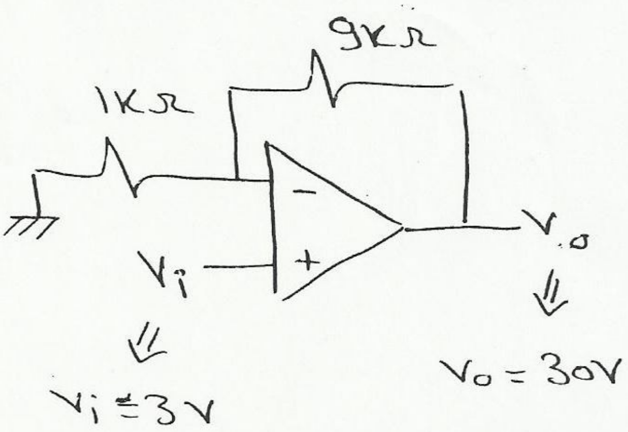
$$\therefore 30 = \left(1 + \frac{R_2}{R_1}\right) * 3$$

$$\frac{R_2}{R_1} = 9$$

$\therefore R_2 = 9 R_1$

let $R_1 = 1k\Omega$

$\therefore R_2 = 9k\Omega$



⇒ Ex.2 : $V_i = 3V$ $V_o = -30V$

Solution !

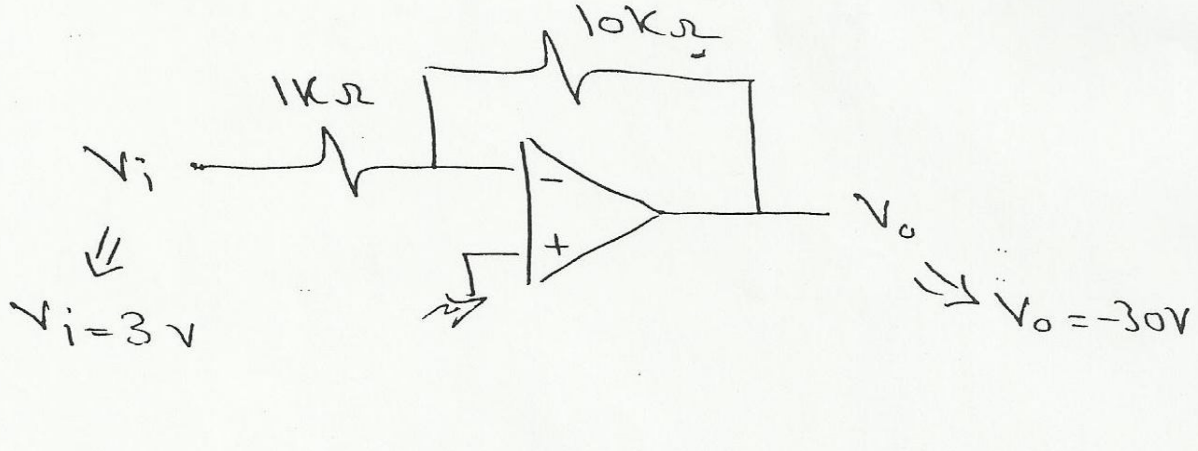
using inverting amp : الإشارة السالبة

$$V_o = -\frac{R_2}{R_1} V_i$$

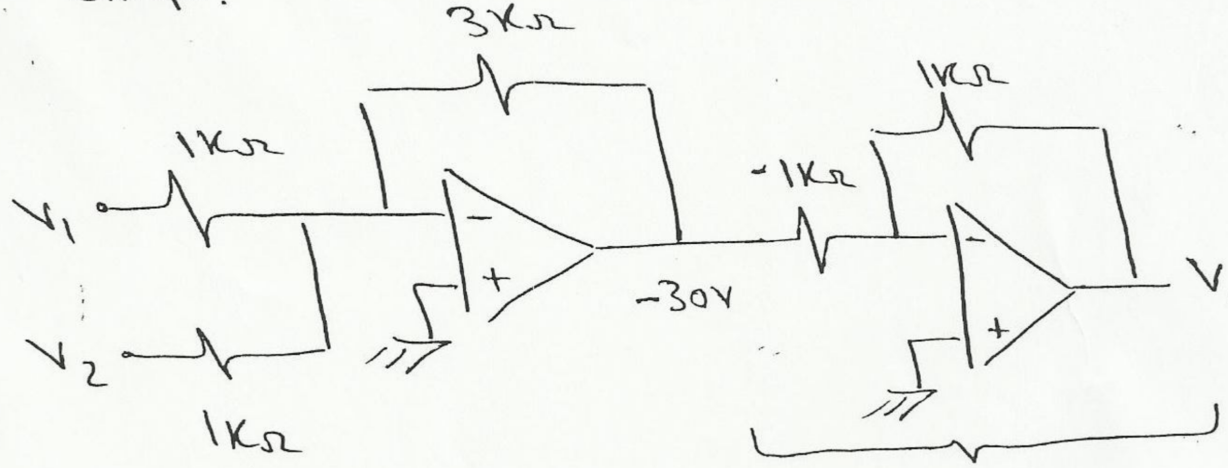
$$-30 = -\frac{R_2}{R_1} * 3$$

$$\therefore R_2 = 10 R_1$$

let $R_1 = 1k\Omega$ $\therefore R_2 = 10k\Omega$



(b) using inverting amp. after the summing amp.



لإنشاء الاشارة السالبة

$$V_o = -\frac{R_2}{R_1}(-30)$$

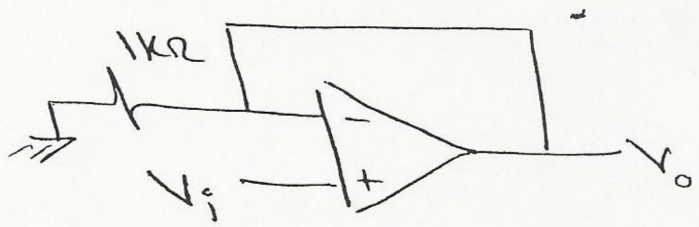
$$= -1(-30)$$

$$= 30V$$

⇒ Ex.4 : $V_i = 3V$ $V_o = 3V$

Solution

using voltage follower:



⇛ **Ex.5:** $V_i = 2t$ and $V_o = -t^2$

Solution

Using Integrating Amp:

$$V_o = -\frac{1}{RC}\int V_i \, dt$$

$$\therefore -t^2 = -\frac{1}{RC}\int 2t \, dt$$

$$= -\frac{1}{RC}\left[t^2 + \overset{\text{ثابت}}{A}\right]$$

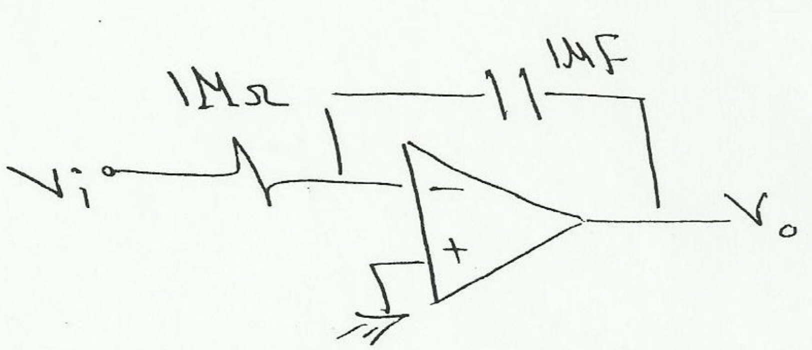
بمقارنة المعاملات :

t^2: $\quad -1 = -\frac{1}{RC} \quad \therefore 1 = \frac{1}{RC} \rightarrow (1)$

t^0: $\quad 0 = -\frac{1}{RC}(A) \quad \therefore A = 0 \rightarrow (2)$

for (1): let $C = 1\mu F$

$$\therefore R = 1\,M\Omega$$



⇛ Ex. 6: $V_i = 3t^2$ $V_o = -9t$

Solution

Using differentiating Amp:

$$V_o = -\frac{1}{RC}\frac{dV_i}{dt}$$

$$-9\cancel{t} = -\frac{1}{RC}\left[6\cancel{t}\right]$$

$$\therefore \frac{1}{RC} = \frac{9}{6}$$

$$\therefore R = \frac{6}{9C}$$

let $C = 1\mu F$ $\therefore R = 0.66\ \underline{M}\Omega$

6 نفس سؤال التصميم :

Given : V_i and V_o

ولكن الإختلاف تحديد نوع ال amp المستخدم في عملية التحويل :

like : $V_i = 3V$ $V_o = -30V$

Using inverting amp.

Design the Cir.

7 Inverse problem :

Given : V_o

Req : The Cir and V_i

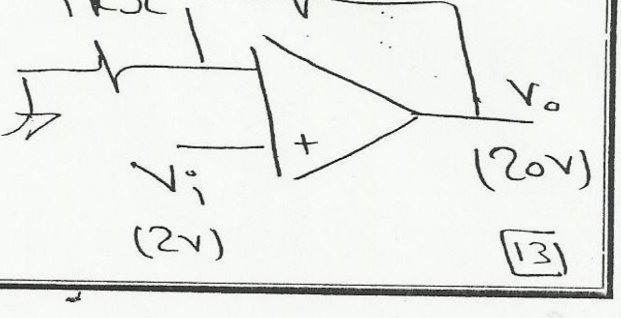
like : $V_o = 20V$

Solution: using noninv. amp for $V_i = 2V$

$$V_o = \left(1 + \frac{R_2}{R_1}\right) V_i$$

$$20 = \left(1 + \frac{R_2}{R_1}\right) * 2$$

$$\therefore R_2 = 9 R_1$$



Part (3)

Op-Amp (Cont.) and Multivibrators

Part (3)

Operational Amplifier (Op-Amp) (Cont.)

Multivibrators

[1] How far is the ideal op-amp compatible with the desired characteristics of amplifier?

[2] Why the desired characteristics in [1] are really desired.

[3] Op-amp buffer and its advantages.

[4] Types, waveforms and uses of each type.

[5] Other known names for the types in [1].

[6] Implementation using the IC555 timer

1 Ideal OP_Amp is fully Compatible with the desired C/CS of Amp.

Ideal OP_Amp C/CS:

(1) $A_v = \infty$

(2) $R_{in} = \infty$

(3) $R_o = 0$

(4) $BW = \infty$

(5) $SR = \infty$

(6) $V_{offset} = 0$

خصائص ال
Ideal OP_Amp
هي نفس الخصائص
التي نريد الوصول إليها
لأي amp.
ولكن من المستحيل
الوصول إليها

2

(1) Gain $= \infty$: because it is desired to reach the max limit of V_o.

(2) $R_{in} = \infty$

حتى تنتقل كل الطاقة (الجهد) من
ال Source إلى دائرة ال Amp ولا يضيع جزء من
المقاومة الداخلية ال Source.

(3) $R_o = 0$

حتى ينتقل كل جهد الخرج إلى

ال load ولا يضيع جزء منه في مقاومة خرج ال Amp.

(4) $BW = \infty$.

حتى يعمل ال Amp. في أى freq range بطريقة

صحيحة.

(5) $SR = \infty$.

حتى لا يكون هناك delay بين دخول ال i/p

وخروج ال o/p ولكى لا يحدث تشوه في الخرج

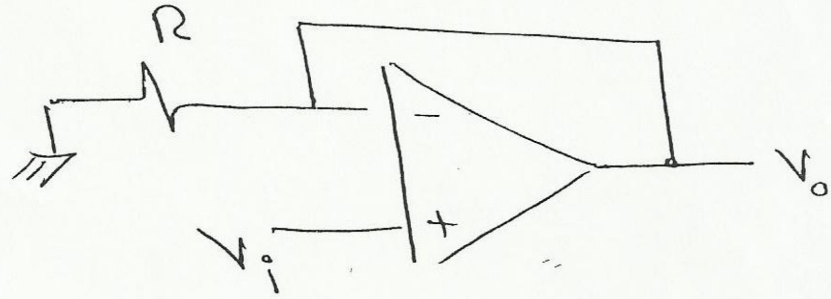
"أى أن الخرج يخرج لحظياً بمجرد دخول ال I/P".

(6) $V_{offset} = 0$

حتى يكون جهد الخرج بصفر عندما يكون

الدخل (بصفر) متصل بالأرض (Ground).

3 OP_Amp Buffer:

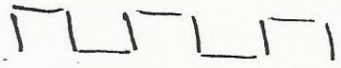
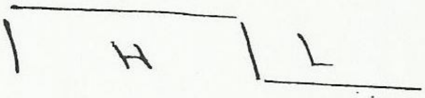
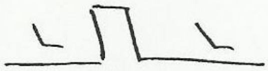


"voltage follower or buffer"

Advs:

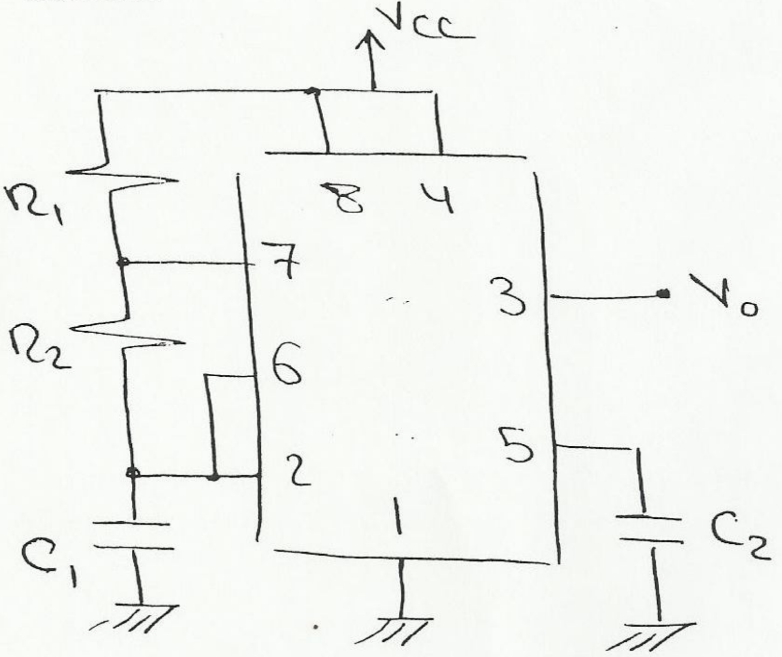
- R_{in} = very high. ($\sim \infty$)
- R_{out} = very low. (~ 0)
- $A_v = 1$ ($V_o = V_i$) << used in many apps. >>

41, 51 Multivibrators

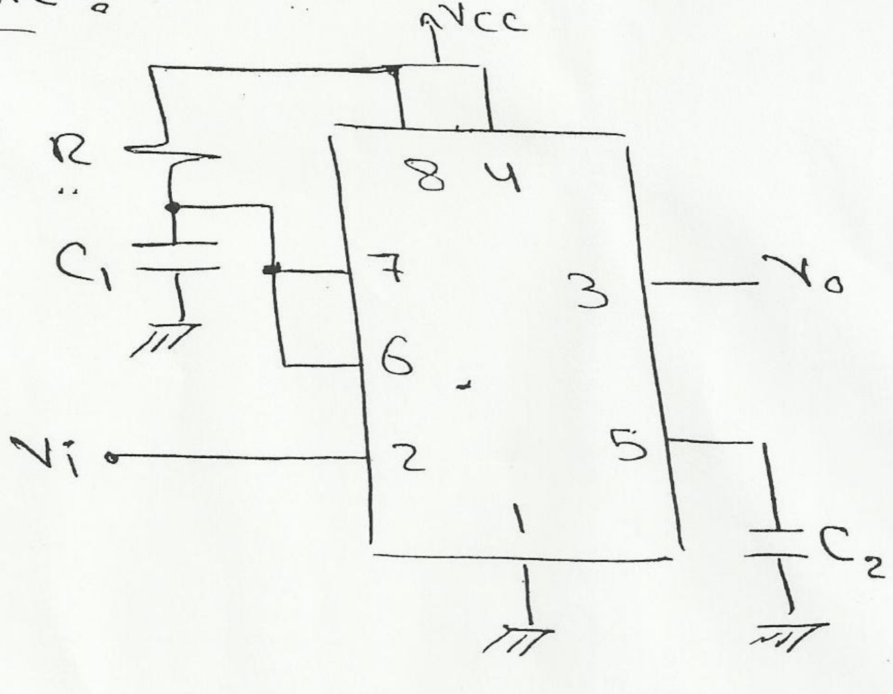
	Type (1)	Type (2)	Type (3)
	Astable	Bistable	Monostable
waveforms	 <<oscillates & never stables>>	 << H or L depends on a SW >>	 ⇑ H <<Trigger>>
Names	• Astable. • free running. • relaxation oscillators	• flip flop • Bistable • Schmitt trigger	• Monostable • one shot.
Uses	→ Square wave generators. → function generators. → System Clock	→ flip flops. → Control Cirs.	→ Control Cirs. → debouncing Switches

6 Multivibrator Types implementation using IC 555:

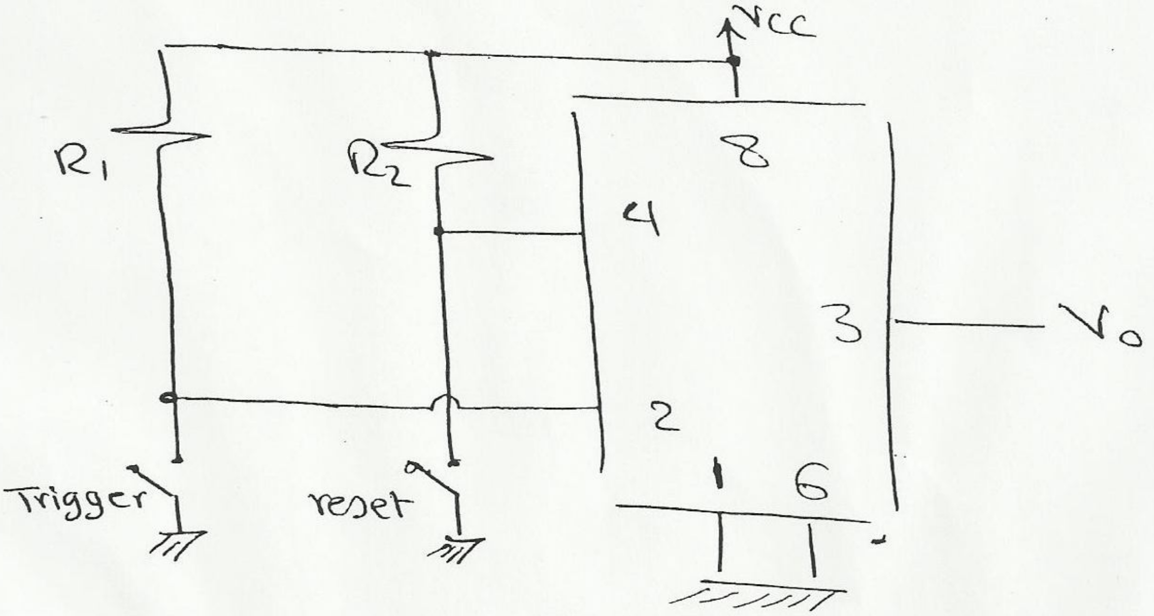
⇛ Astable:



⇛ Monostable:



⇒ Bistable :



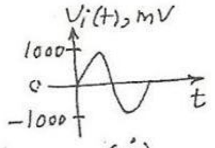
Mansoura Univ.
Faculty of Eng.
Electronics & Comm. Eng. Dept.

2 hrs.

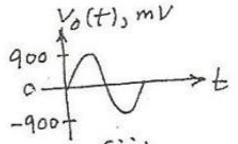
LAB II
Final Exam
Jan. 2013

---

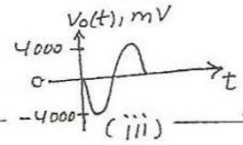
1. A BJT amplifier stage has the input waveform in Fig. i. State the type of the amplifier (CE, CB or CC) if the output waveform is as shown in:
(a) Fig. ii (b) Fig. iii (C) Fig. iv.



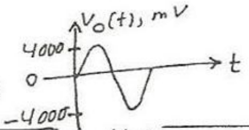
(i)



(ii)



(iii)



(iv)

---

2. (a) Which of the following BJT amplifiers has good input impedance and/or good output impedance: (i) CE (ii) CC (iii) CB.
(b) In terms of Hi or Lo, what is meant by the word "good" in (a).

---

3. State some situations where FETs are preferred to BJTs.

---

4. In an op-amp circuit (excluding the comparator), mention the ideal values of : (a) I_+ , (b) I_- , (C) $V_+ - V_-$.

---

5. (a) sketch a voltage follower op-amp circuit.
(b) Give another name for the circuit in (a) and the reason for that name.

---

6. It is required to sketch an op-amp circuit having inputs $V_1(t)$ and $V_2(t)$ and output $V_2(t) - V_1(t)$, using:
(a) two op-amps (b) single op-amp.

---

7. Give one more name and state one application for each of the following multivibrators:
(a) mono stable (b) bistable (c) astable.

---

8. (a) Show how to construct an astable multivibrator using IC 555, necessary resitors, capacitors and power supply.
(b) Write (without proof) expressions for the frequency and duty cycle of the multivibrator in (a).

END

Exam 2013

[1] (a) CC Configuration : $A_v \leq 1$

Phase shift = 0°

(b) CE Configuration : $A_v = \uparrow\uparrow$

Phase shift = 180°

(c) CB Configuration : $A_v = \uparrow\uparrow$

Phase shift = 0°

DREAM

---

[2] (a) CC : Very good i/P imp.

" " o/P imp.

CE : good i/P imp.

CB : good o/P imp.

"الأفضل هو ال CC بالنسبة لل i/P & o/P imp"

(b) Good i/P imp ≡ High imp.

Good o/P imp ≡ Low imp.

|3| Some Situations:

(1) Building ICs (Integrated CirCuits):

→ beCause FET has smaller size than BJT.

(2) Designing wireless devices:

→ beCause FET Consume less power than BJT (الحفاظ على فترة عمر البطارية).

(3) Construct a VCCS (Voltage Controlled Current Source).

(4) Construct a thermally stable sys.

(5) InCrease the i/p imp. of a Cir.

4 ⇒ Advs of FET over BJT:

- ⇛ Smaller size.
- ⇛ Lower power Consumption.
- ⇛ higher i/p imp.
- ⇛ higher thermal stability.

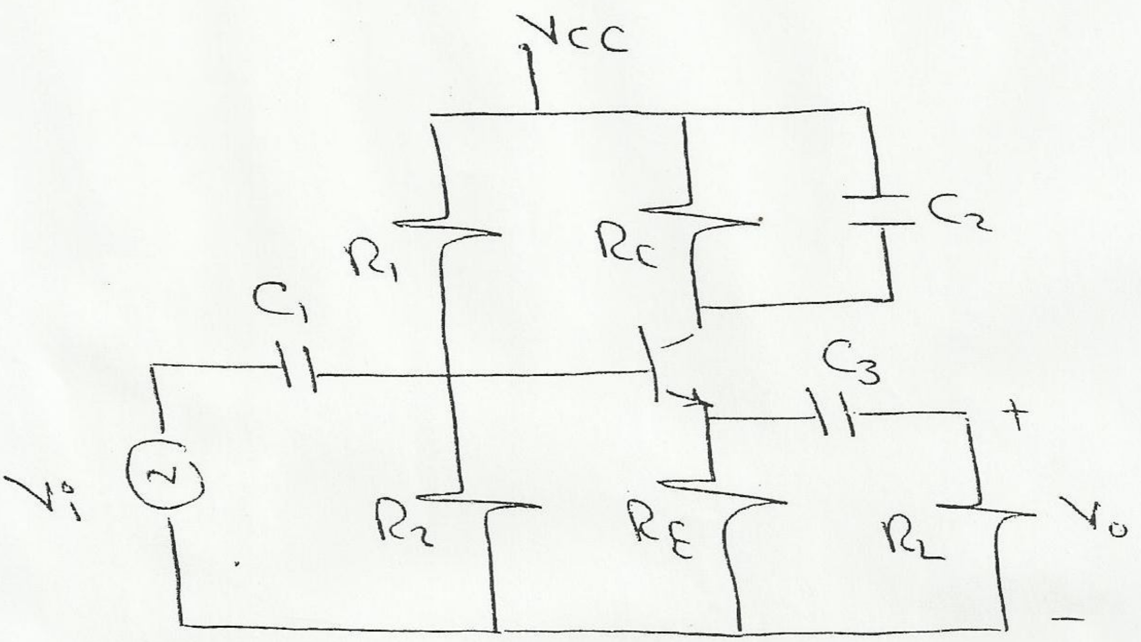
4 (a) $I^+ = 0A$

(b) $I^- = 0A$

(c) $V^+ - V^- = 0V$

---

5 (a) Voltage follower :



(b) ⇛ CC :

reason : I/P ≡ B   O/P ≡ E

⇛ Voltage Buffer :

reason : 1- $A_v \simeq 1$ $(V_o \simeq V_i)$

يقوم بعمل حفظ لجهد الدخل

2- Z_{in} = ↑↑↑ (very high)

$\boxed{6}$ Solved in Part (2) : $\boxed{Q\,4}$.

Subtraction using single and double OP-Amps:

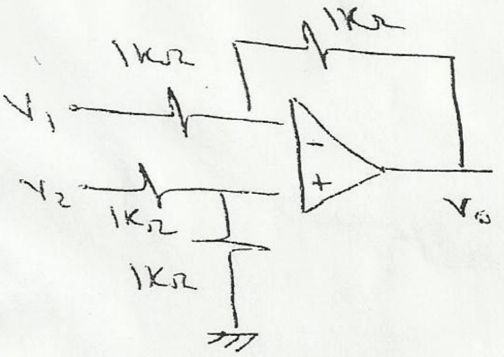
الفارق أننا نريد جعل ال gain = ١ أي أن

$V_o = V_2 - V_1$

:. نضع جميع المقاومات = $1K\Omega$ مثلاً :.

DREAM
01012045000 - 01012046000

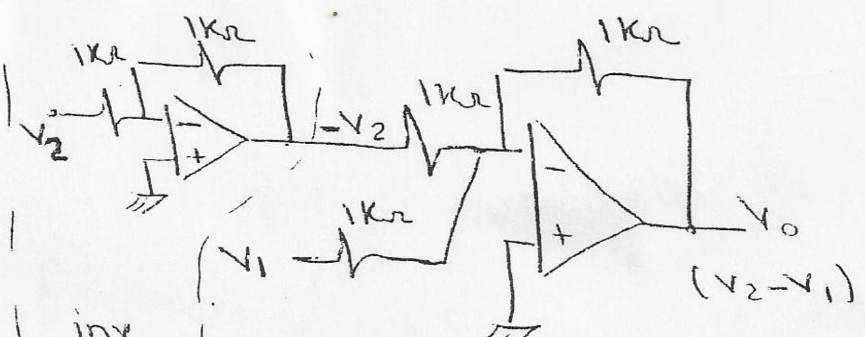
Single



Subtracting Amp.

$V_o = V_2 - V_1$

Double



inv Amp

$V_o = -V_2$

Summing amp

$V_o = V_2 - V_1$

$\boxed{7}$ Solved in Part (3) Page (4).

$\boxed{8}$ ⓐ Solved in Part (3) Page (5)

ⓑ

$$f = \frac{1}{\ln(2)\, C_1 (R_1 + 2R_2)} = \frac{1.44}{C_1 (R_1 + 2R_2)}$$

$$\text{Duty Cycle} = \frac{T_{on}}{T_{on} + T_{off}} = \frac{R_1 + R_2}{R_1 + 2R_2}$$